

Technical Assistance to the City of
Birmingham, Alabama

CSI Resource Systems, Inc.
Boston, MA

Prepared for

Environmental Protection Agency
Atlanta, GA

Oct 80

U.S. Department of Commerce
National Technical Information Service

NTIS

REPORT DOCUMENTATION PAGE		1. REPORT NO.	2.	3. Recipient's Accession No. PR82 206434	
4. Title and Subtitle Technical Assistance to the City of Birmingham, Alabama				5. Report Date October 1980	
7. Author(s)				6.	
9. Performing Organization Name and Address CSI Resource Systems, Inc. Boston, Massachusetts				8. Performing Organization Rept. No.	
				10. Project/Task/Work Unit No. Work Assignment 19	
				11. Contract(C) or Grant(G) No. (C) 68-01-6004 (G)	
12. Sponsoring Organization Name and Address Office of Solid Waste Management U.S. Environmental Protection Agency Region IV, Atlanta, Georgia				13. Type of Report & Period Covered	
15. Supplementary Notes				14.	
16. Abstract (Limit: 200 words) This study (Phase II) details technical assistance rendered the City of Birmingham, Alabama, in the area of solid waste management and is the result of a Phase I visit of March 20, 1980. The report entails the review and evaluation of costs-reduction plans developed by the Birmingham Department of Streets and Sanitation, identification of other costs-reducing methods, and a review and analysis of current collection equipment with a plan to reduce overall systems costs, including manpower. This report represents Phase II of the project.					
17. Document Analysis a. Descriptors Solid Waste Management; Phase II					
b. Identifiers/Open-Ended Terms Birmingham (Alabama) ~~(BMRCS) Birmingham Municipal Residential Collection System~~ ~~(BDS&S) Birmingham Department of Streets and Sanitation~~					
c. COSATI Field/Group					
18. Availability Statement Release to Public		19. Security Class (This Report) Unclassified		21. No. of Pages	
		20. Security Class (This Page) Unclassified		22. Price	

United States
Environmental Protection
Agency

Region 4
345 Courtland Street, NE
Atlanta, GA 30303

October 1982

PB82-206434

EPA A TECHNICAL ASSISTANCE PROGRAM REPORT

TECHNICAL ASSISTANCE TO THE CITY OF BIRMINGHAM, ALABAMA

REPRODUCED BY
**NATIONAL TECHNICAL
INFORMATION SERVICE**
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

Public Law 94-580 - Oct. 21, 1976

Technical assistance by personnel teams. 42 USC 6913

RESOURCE RECOVERY AND CONSERVATION PANELS

SEC. 2003. The Administrator shall provide teams of personnel, including Federal, State, and local employees or contractors (hereinafter referred to as "Resource Conservation and Recovery Panels") to provide States and local governments upon request with technical assistance on solid waste management, resource recovery, and resource conservation. Such teams shall include technical, marketing, financial, and institutional specialists, and the services of such teams shall be provided without charge to States or local governments.

This report has been reviewed by the Project Officer, EPA, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Project Officer: Elmer G. Cleveland

U. S. ENVIRONMENTAL PROTECTION AGENCY
TECHNICAL ASSISTANCE PROGRAM REPORT SERIES

TECHNICAL ASSISTANCE TO
THE CITY OF BIRMINGHAM, ALABAMA

PREPARED FOR
OFFICE OF SOLID WASTE MANAGEMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV, ATLANTA, GEORGIA

BY
ENGINEERING-SCIENCE, INC.
ATLANTA, GEORGIA

AND
CSI RESOURCE SYSTEMS, INC.
BOSTON, MASSACHUSETTS

OCTOBER, 1980

TABLE OF CONTENTS

		<u>Page</u>
CHAPTER 1	SUMMARY OF FINDINGS AND CONCLUSIONS	1-1
	BMRCs System Performance	1-2
	Evaluation of BMRCs System Performance	1-2
	Cost Reduction Plans	1-4
	Alternate Cost Savings Measures	1-8
	Cost Savings through Alternate Equipment	
	Type Usage	1-9
	System Safety	1-9
CHAPTER 2	CURRENT COLLECTION SYSTEM DESCRIPTION AND EVALUATION	2-1
	System Description	2-1
	Service Area	2-1
	Level of Service	2-2
	Crews and Routes	2-2
	Equipment	2-2
	Operation	2-3
	Collection System Performance	2-5
	Method of Productivity Analysis	2-5
	Study Period	2-6
	BMRCs Productivity	2-7
	Evaluation of Collection System Performance	2-10
	Method of Evaluation	2-10
	Evaluation of Productivity	2-11
	Evaluation of Cost Efficiency	2-15
CHAPTER 3	RESIDENTIAL REFUSE COLLECTION SYSTEM COST REDUCTION ALTERNATIVES	3-1
	Cost Reduction Plans Developed by the BDS&S	3-1
	Description of Plans	3-1
	Economic Feasibility of Plans	3-2
	Technical Feasibility of Plans	3-3
	Plan I	3-3
	Plan II	3-7
	Plan III	3-9
	Plan IV	3-10
	Tentative Plan	3-11
	Tentative Plan with One Person Crews	3-14
	Summary	3-17
	Alternative Cost Savings Measures	3-17
	Additional Crew Reductions	3-17
	Utilization of 3 Person Crews	3-18
	Equipment Changes	3-24
	Routing	3-24

CHAPTER 4	COST SAVINGS THROUGH ALTERNATE EQUIPMENT	
	TYPE USAGE	4-1
	Present Equipment Inventory	4-1
	Method of Cost Reduction	4-2
	Cost Analysis	4-3
	Summary	4-11
CHAPTER 5	BIRMINGHAM SYSTEM SAFETY	5-1
	Safety Record	5-1
	Collection Procedures	5-2
	Worker Safety	5-2
	Equipment Safety	5-2

LIST OF FIGURES

Number	Title	Page
2.1	Productivity for Birmingham and Comparison Systems	2-14

LIST OF TABLES

Number	Title	Page
1.1	Cost Reducing Plans Developed by the BDS&S	1-5
1.2	Feasibility Summary for Cost Reducing Plans	1-6
1.3	Cost Reduction Estimates	1-7
2.1	BMRCs Packer Vehicle Inventory Summary	2-4
2.2	BMRCs Garbage Collection Productivity	2-8
2.3	Summary of Productivity Affecting Factors for Birmingham	2-9
2.4	Operating Parameters for Birmingham and Comparison Systems	2-12
2.5	Productivity of BMRCs and Comparison Systems	2-13
2.6	Cost Efficiency of BMRCs and Comparison Systems	2-17
3.1	Cost Reduction Estimates	3-4
3.2	Estimated Task Times for Present System and Plan I System	3-5
3.3	Productivity for Two Walker Crews	3-8
3.4	Estimated Task Times for System Alternatives	3-13
3.5	Feasibility Summary for Cost Reducing Plans	3-16
3.6	Determination of Equivalent 3 Person Crew Systems	3-20
3.7	Cost Estimates for Comparison 1	3-21
3.8	Cost Estimates for Comparison 2	3-22
4.1	Estimate of Time Spent on Landfill Trips Using Present Equipment Inventory (System A)	4-4
4.2	Time Utilization Estimates for Systems A and B	4-6
4.3	Life Cycle Costs - 20 Cu Yd Rear Loader (Conventional)	4-7
4.4	Life Cycle Costs - 20 Cu Yd Rear Loader (Auger Type)	4-8
4.5	Annual Cost Estimate - System Using Present Equipment Inventory (System A)	4-9
4.6	Annual Cost Estimate - System Using Only Auger Type Packers (System B)	4-10
5.1	Summary of Data from First Three Quarters of EPA Safety Study	5-3

CHAPTER 1
SUMMARY OF FINDINGS AND CONCLUSIONS

CHAPTER 1

SUMMARY OF FINDINGS AND CONCLUSIONS

The City of Birmingham, Alabama submitted a request to the Region IV EPA office for technical assistance in the area of solid waste management. As a result of this request a Phase I site visit was authorized. During the Phase I visit of March 20, the following list of objectives was developed for Phase II of the project.

- o Review and evaluate plans which were developed by the Birmingham Department of Streets and Sanitation (BDS&S) to reduce costs in the existing residential waste collection system.
- o Identify other methods or plans for reducing costs that may be applicable to the Birmingham Municipal Residential Collection System (BMRCs).
- o Review the BDS&S current collection equipment inventory with respect to its future utility and identify alternative equipment types needed in conjunction with any one of the plans for reducing overall system costs.

Based on the Phase I results the Technical Assistance to the City of Birmingham, Alabama, Phase II project was approved. The work associated with this study has been completed. A summary of the information that was developed during the course of the study and major conclusions of the study are presented in this chapter. The details of the various aspects of the study are presented and discussed in Chapters 2 through 5.

1. BMRCs SYSTEM PERFORMANCE

The BMRCs provides twice per week, curb side garbage collection service to the residents of Birmingham. Also trash (yard wastes, etc.) is collected once per week from each resident. An analysis was performed to determine the productivity of the BMRCs (four days per week garbage collection only). The details of the productivity analysis are presented in Chapter 3. The basic data used for this analysis consisted of per crew task time measurements (from daily log sheets), per route house counts and estimates of time spent on necessary nonproductive tasks (landfill trips, etc.). A time/motion study was also performed to obtain short term measurements of collection crew productivity. The productivity analysis produced the following findings.

- 1.1 The estimated average per crew productivity for the BMRCs is as follows:

Summer months	- 295 pick-ups/crew-hr
Winter months	- 327 pick-ups/crew-hr
Year-round average	- 311 pick-ups/crew-hr

(based on on-route time)

These estimates were the result of a system wide productivity analysis. This general magnitude of productivity is consistent with results of time/motion measurements that were taken during the course of this study (average 327 pick-ups/crew-hr)

- 1.2 It was observed that there was a deviation in year-round productivity between the four geographical districts in Birmingham ($\pm 13\%$). It is believed that deviations of this magnitude could be caused by physical differences between the districts (population density, etc.) and/or differences in crew efficiency.

2. EVALUATION OF BMRCs SYSTEM PERFORMANCE

The BMRCs was evaluated by comparing its productivity and cost efficiency with those of other systems offering the same basic level

of service (referred to as the Comparison Systems). The Comparison Systems were the subject of a detailed one year EPA study to evaluate the systems' productivity. The Comparison Systems were selected by the EPA as being "highly productive" and only the four most efficient crews from each system were monitored. The Comparison Systems are similar to the BMRCs in many ways but do differ based on crew size, equipment type and collection methodology. The details of the comparison are given in Chapter 3. The findings and conclusions from the productivity and cost efficiency comparisons are given below.

- 2.1 The per walker productivity of the BMRCs (104 pick-ups/walker-hr) was found to be similar to the per walker productivities of the Comparison Systems (average 107 pick-ups/walker-hr). It was concluded that the BMRCs and the Comparison Systems are directly comparable on a per walker productivity basis since the walkers' tasks are similar for all of the systems.
- 2.2 The per crew productivity of the BMRCs was found to be greater than those of the Comparison Systems. This is due to the facts that the per walker productivities for all the systems are similar and the BMRCs uses a larger per crew work force.
- 2.3 The unit service cost (cost per home served per week) of the BMRCs was found to be lower than those of the Comparison Systems (based on a comparison using equivalent item costs). It was concluded that the four systems are directly comparable on a cost efficiency basis because they all offer the same nominal level of service.
- 2.4 Based on the comparative analysis it is concluded that the BMRCs, as presently operated, is a highly productive and cost efficient refuse collection system when compared to other systems offering the same nominal level of service.

3. COST REDUCTION PLANS

Prior to the beginning of this study the Birmingham Department of Streets and Sanitation (BDS&S) developed four cost reducing plans for the refuse collection system. At a later date a tentative decision was made concerning a specific course of action for system changes. This "tentative plan" is a modification of one of the previously developed plans. The plans are briefly described in Table 1.1. The technical and economic feasibility of each plan was evaluated (see Chapter 4) and the results are summarized in Table 1.2. The following conclusions concerning the cost reduction plans were formed.

- 3.1 The cost savings estimates calculated by the BDS&S for the four plans (I through IV) were accurate and reasonable except for the omission of employee absenteeism (vacation and sick leave). The original and corrected estimates are tabulated in Table 1.3. Inclusion of employee absenteeism increased the cost savings estimates in all cases.
- 3.2 It was concluded that Plan I and the Tentative Plan each have a good potential for technical and economic success with the BMRCS.
- 3.3 It is believed that the Tentative Plan is superior to Plan I since garbage and trash would be collected simultaneously (they would still be collected separately with Plan I). It is very likely that simultaneous collection of garbage and trash will be more efficient than separate collection.
- 3.4 It was concluded that the potential for success of Plan IV and the Tentative Plan with One Person Crews is questionable. This conclusion was based on consideration of a variety of problems which can occur with this type of one person system and the relatively small cost savings that would be achieved.
- 3.5 Plan II is considered to have poor potential for success with the BMRCS. It was estimated that due to a reduction in per crew productivity, the average task time

TABLE 1.1

COST REDUCING PLANS DEVELOPED BY THE BDS&S

Plan I

- o Reduction of the number of crews from 33 to 29.
- o Altering the remaining 29 crews' routes to provide complete coverage.

Plan II

- o Reduction of the crews' size from 4 persons to 3 persons.
- o No reduction in the total number of crews; routing remains the same.

Plan III

- o Reduction of the level of service from twice per week collection to once per week collection.
- o Reduction of the number of crews from 33 to 25.

Plan IV

- o Replacement of 4 regular crews with 4 one-person crews using mechanically loading packer vehicles (used only in areas of town where alleys exist).

Tentative Plan

- o Reduction of the number of crews from 33 to 29.
- o Alter routes to provide complete coverage.
- o Change from 5-day work week to 4-day work week.
- o Collect trash and perform clean-up along with a garbage collection (each route traveled twice per week).

Tentative Plan with One Person Crews

- o Same as Tentative Plan except 27 four-person crews are used plus two one-person crews (same type of collection as considered under Plan IV).

TABLE 1.2
FEASIBILITY SUMMARY FOR COST REDUCING PLANS

Estimated Relative Potential for Successful Application
to Birmingham System(2)

<u>Cost Reducing Plan(1)</u>	<u>Good</u>	<u>Questionable</u>	<u>Poor</u>
Plan I	X		
Plan II			X
Plan III			X
Plan IV		X	
Tentative Plan	X		
Tentative Plan with One-Person Crews		X	

(1) See Table 1.1 for plan descriptions.

(2) Estimate of economic and/or technical potential of success.

TABLE 1.3
COST REDUCTION ESTIMATES

<u>Estimated Cost Reduction Over Present System (\$/year)(1)</u>		
	<u>BDS&S Original(2)</u>	<u>Estimate Adjusted</u>
	<u>Estimate</u>	<u>for Absenteeism(3)</u>
Plan I	260,100	272,400
Plan II	388,200	410,600
Plan III	520,200	544,900
Plan IV	42,100	47,000(4)
Tentative Plan	-	272,400(5)
Tentative Plan with One- person crews	-	306,500(5)(6)

- (1) All estimates are based on certain assumptions which were made by the BDS&S. The savings could vary significantly based on assumptions made concerning equipment life, container life, etc.
- (2) Estimates made by BDS&S using January 2, 1980 cost figures.
- (3) Assume: 2 weeks per year per person vacation
1 week per year per person sick leave
- (4) Since the BDS&S estimates were made it has been proposed to eliminate the use of 400, 90-gallon containers from the original plan. This has added about \$4000/year to the savings for Plan IV. This savings results from use of 4 one-person crews only. Additional savings could be derived by applying cost savings concepts similar to other plans with the remaining full crews.
- (5) These plans had not been developed when BDS&S made original cost estimates.
- (6) Does not include cost for any equipment back-up system. This estimate allows for 2 one-person crews. As many as 2 more could be added in the future.

could exceed 40 hours per worker per week. This could require overtime pay (1.5x) on a regular basis or addition of more crews. These extra costs could reduce or negate the cost savings derived from the Plan.

- 3.6 Plan III is considered to have poor potential for success with the BMRCs. The conclusion is based on the fact that once per week collection could create a public health hazard and/or nuisance. It is believed that, at least in summer, once per week collection might create a fly problem in Birmingham.

4. ALTERNATE COST SAVINGS MEASURES

Several concepts for further reducing BMRCs costs (beyond the plans developed by the BDS&S) were examined in Chapter 4. The following conclusions were formulated.

- 4.1 Further crew reductions (similar to those of Plan I and the Tentative Plan) might be used to reduce BMRCs costs. However, there are system problems that can occur if this philosophy is carried too far. Careful consideration of the possible system impacts should be made before further crew reductions are implemented.
- 4.2 It is possible that the BMRCs could be converted to a 3-person crew system. However, it would probably be necessary to operate the system with more than 33 crews (the number of crews presently being used). At the present BMRCs per walker productivity level (104 pick-ups/walker-hr) 3-person crews would not be as cost effective as 4-person crews. For 3-person crews to become more economically attractive than 4-person crews productivity levels greater than 258 pick-ups/crews-hr and 129 pick-ups/walker-hr would have to be achieved (24% higher per walker productivity than the present system). It is unlikely that these productivity levels could be achieved, given the available information on productivity for other

3-person crew systems. In many refuse collection situations it has been found that 3-person crews are more cost effective than 4-person crews. This, however, does not appear to be the case with the BMRCs. It is believed that this is due to the fact that (1) the third walker (fourth person) appears to be well utilized and (2) the BMRCs crews work in such a manner that the third walker does not interfere with the other walkers (thus diminishing the crew's net productivity).

4.3 It is likely that there is potential for cost savings in the following areas.

- o Improved routing of the collection crews.
- o Alternate collection vehicle type usage (see 5 below).

5. COST SAVINGS THROUGH ALTERNATE EQUIPMENT TYPE USAGE

An illustrative example was developed (using the BMRCs as a basis) showing how the use of a high compaction packer vehicle can increase a crew's daily on-route time without increasing the total task time. The example shows how this can be converted to a net reduction in the number of crews required to perform city wide collection. As would be expected, this can produce a total system cost savings. The details of the analysis are given in Chapter 5. Based on this analysis the following conclusion was formed.

5.1 The use of high compaction packer vehicles by the BMRCs could have potential for providing a system operating cost reduction. A detailed study of the number of landfill trips and the crew time that these trips are consuming would be necessary to evaluate the feasibility of this concept.

6. SYSTEM SAFETY

The collection worker safety aspects of the BMRCs were reviewed. The BMRCs along with 55 other systems participated in a detailed

EPA study of accident occurrence and severity in 1976. The third quarter results of this study were reviewed. Also, personnel practice and equipment safety were observed during on-route observation. The topic of safety is discussed in Chapter 5 and the major findings are listed below.

- 6.1 During the first three quarters of the EPA safety study the BMRCs had a lower accident rate (based on number and severity of accidents) than the average for all the study systems. The per worker accident costs for the BMRCs were also lower than the average.
- 6.2 During observation periods it was noted that the BMRCs crews, for the most part, followed reasonably safe procedures. However though no accidents were observed, there were some instances when unsafe procedures were used. These instances are noted in Chapter 5.

CHAPTER 2.

CURRENT COLLECTION SYSTEM DESCRIPTION AND EVALUATION

CHAPTER 2

CURRENT COLLECTION SYSTEM DESCRIPTION AND EVALUATION

The objective of this chapter is to present information concerning the characteristics of the Birmingham Municipal Refuse Collection System (BMRCs) as it is presently structured and operated. An evaluation of the BMRCs with respect to productivity and cost efficiency is also presented.

SYSTEM DESCRIPTION

Service Area

At present the BMRCs services approximately 89,200 pick-up locations within the Birmingham city limits. The BMRCs collects refuse from residences, small churches, apartment buildings and small commercial establishments.

Though most of the city's commercial refuse is collected by private haulers, the BMRCs does operate one crew which services some of the smaller commercial establishments in the downtown area. At present there are no plans to alter this service so this one route will not be discussed in the remainder of this report.

For management purposes the city has been divided into four districts:

<u>District Name</u>	<u>Approximate Number of Services</u>
South Side	19,500
Ensley	24,500
East End	21,000
North Birmingham	24,200

The BMRCs has a supervisor for each district and an equipment storage area within each district.

Level of Service

The level of service provided by BMRCs is as follows:

- o Twice per week garbage collection from each residence (household refuse)
- o Once per week trash collection from each residence (landscape wastes and miscellaneous debris)
- o Curbside service in most areas; alley service in areas where alleys exist
- o Bag and/or can containerization

Crews and Routes

At present the BMRCs consists of a total of 33 residential collection crews (not including the one commercial crew previously mentioned). These crews are divided among the four districts as follows:

South Side	- 8
Easley	- 9
East End	- 8
North Birmingham	- 8

Each crew is responsible for garbage and trash collection on two routes (note that route, when mentioned here, will refer to the area serviced by one crew in one garbage collection day). On Monday and Thursday, garbage is collected from one route; on Tuesday and Friday, from the other route. On Wednesday each crew is responsible for trash pick-up and general clean-up on both of its routes.

The crews are made up of four persons each. One person is responsible for driving the collection vehicle and acts as a crew chief (driver). The other three crew members are responsible for loading refuse into the collection vehicle (walkers). As a rule, drivers do not regularly help to load refuse. At present the drivers are listed as classified employees and are paid at a higher rate (salaried) than the unclassified walkers (per hour).

Equipment

The BMRCs uses rear-load type packer vehicles for solid waste collection. Each crew is assigned a packer and uses the same

vehicle regularly unless there is an equipment failure. The BMRCs has a number of spare packers which can be used to temporarily replace broken-down service vehicles. For the most part, these replacement vehicles are older packers which have been taken out of regular service.

Table 2.1 summarizes the BMRCs packer vehicle inventory. Most of the vehicles currently being used are 20-cu yd rear loaders with conventional compacting mechanisms. The average age for the vehicles in regular use is 3.2 years. The BMRCs presently uses five 25-cu yd rear-loaders with conventional compacting mechanisms; average age also 3.2 years. At present four 20-cu yd rear loaders with auger type compacting mechanisms have been purchased and are in regular service. This type of vehicle is not widely used in the United States at the present time. The BMRCs management has been pleased, so far, with the service that these vehicles have been providing and their ability to achieve a high degree of compaction.

Operation

The BMRCs is presently operated on a task incentive system. Under this system, refuse collection vehicles leave the yard between 6:00 and 6:30 A.M. The crews work their routes and make trips to the landfill as needed. When the route has been satisfactorily completed and the trucks have been washed, the crews are free to leave work. The basis of the incentive program is that the personnel are paid for 8 hours of work regardless of how long it takes. It is estimated that the system-wide average per crew task time is about 6.1 hr/day (see productivity analysis later in this chapter).

As previously stated, the BMRCs collects trash and garbage from streets and, where present, alleys. In most cases, a one-pass method is used for street collection (i.e., refuse from both sides of the street is collected on a single pass). However, in a few instances where physical limitations exist two-pass collection methodology is used.

TABLE 2.1
BMRCS PACKER VEHICLE INVENTORY SUMMARY

<u>Vehicle Type</u>	<u>Age (yr)</u>	<u>Number</u>		
		<u>Regular Service</u>	<u>Total</u>	<u>Reserve</u>
Rear load,	1	2	2	0
20-cu yd,	2	9	9	0
Conventional	4	8	10	2
compacting	5	5	7	2
mechanism	6	0	4	4
	7	0	1	1
	8	0	8	8
	9	0	1	1
	10	0	1	1
	11	0	1	1
	12	0	1	1
Rear load,	3	4	4	0
25-cu yd,	4	1	2	1
Conventional				
compacting				
mechanism				
Rear load,	NEW	2	2	0
20-cu yd,	1	2	2	0
Auger type				
compacting				
mechanism				
TOTAL		33	55	22

COLLECTION SYSTEM PERFORMANCE

The objective of this section is to present the results of a productivity analysis of the BMRCs which was done for the purposes of this study.

Method of Productivity Analysis

Productivity of municipal refuse collection systems is often expressed in the following terms:

- o weight of refuse collected per crew per hour
- o number of residences (pick-ups) per crew per hour

Common variations include per crew member and per walker expressions for productivity.

Weight collected productivity measurement (ton/crew-hr, etc.) requires weight records for the full refuse vehicles. Because refuse production rates can be highly variable over short periods, it is necessary to collect a considerable number of weight measurements over an extended period of time to develop a meaningful data base. A task of this magnitude for a city as large as Birmingham is beyond the scope of this study. Other methods of productivity measurement will be used here and weight measurements are not necessary to achieve the objectives of this study.

Productivity measured in terms of service provided was used as the basic measurement of productivity for the purposes of this analysis. These measurements can be made much easier and more accurately over a short period of time than weight measurements. It will also be possible to make use of daily time logs which were provided by the Birmingham Department of Streets and Sanitation (BDS&S) to estimate productivity over the past 1-year period.

The basic unit of productivity which is used here is "pick-ups/crew-hr." This is an expression of the average number of pick-ups each crew or group of crews is making per on-route hour. It is important to remember that, in this case each home is serviced twice per week (i.e., homes served/crew-hr is equal to one half the pick-ups/crew-hr). To avoid confusion, pick-ups/crew-hr, pick-ups/crew-member-hr or pickups/walker-hr will be used exclusively here.

Two basic pieces of information are needed to determine system productivity:

- o The average time spent on route (daily or weekly)
- o The average total number of pick-ups made during this time period.

For the purposes of this report on-route time will be referred to as productive time while off-route time (though much of it is necessary) will be referred to as non-productive time. The necessary productive time information was determined, in this case, by subtracting the daily off-route (non-productive) time (traveling to route, landfill trips, vehicle washing) from the total daily task time. The average total daily times for each district were obtained from log sheets which the drivers fill out daily. The average non-productive time was estimated for each crew and district with the aid of BMRCs personnel. Per route house counts were made by the BMRCs district foremen.

A sensitivity analysis was done on the productivity calculation method used. The objective was to see how error in the non-productive time estimates would impact the calculated productivity values. It was found that an error of $\pm 50\%$ in the non-productive time estimate produced an error in the calculated productivity of about $\pm 20\%$. It is believed that the non-productive time estimates are well within a $\pm 50\%$ range, and that the error caused by the estimate in the calculated productivity is less than $\pm 20\%$.

Study Period

Refuse collection crew productivity often varies considerably on a seasonal basis. In Birmingham, the summer collections normally take longer than the winter collections due to higher refuse generation (more landfill trips) and more difficult working conditions. To account for this, two 2-month periods were studied: one during the winter (January and February, 1980); the other during the summer (June and July, 1979). These periods were studied separately and then averaged to estimate year-round productivity.

BMRCs Productivity

Table 2.2 presents the results of the productivity analysis of the BMRCs. The productivity has been analyzed for 4-day per week garbage collection only (Wednesday trash collection is not included). Also shown on Table 2.2 is the basic data which were used to calculate the system's productivity.

The following observations concerning the BMRCs productivity are noteworthy.

- o The estimated year-round, system-wide average productivity for the BMRCs is 311 pick-ups/crew-hr.
- o The average winter productivity for the individual districts ranged from 4% to 23% higher than the average summer productivity.
- o The average productivity for the Ensley and East End districts was about the same. The South Side productivity averaged about 11% less and the North Birmingham productivity averaged about 15% more than the other two districts.

The occurrence of the difference in seasonal productivity was expected and some major reasons have been previously noted. The reasons for the difference in the district productivities could easily be due to one or more of a variety of reasons; a few of which are noted below:

- o District population density
- o Population affluence
- o District topography
- o Number of one-way streets
- o Differences in crew efficiencies

BDS&S personnel were questioned concerning general physical differences between the four districts. This information is summarized in Table 2.3. The information concerning population density and topography was supported quite well by the productivity data. The information concerning affluence was difficult to evaluate since the most generally affluent district (East End) has about average productivity. None of the considerations directly conflicted with the productivity

data. Based on this analysis it is believed that there are physical differences between the four districts which tend to influence garbage collection productivity in Birmingham.

During the course of this project, a time/motion productivity study was done. The measurements were taken on one day in June during 10 hours of on-route observation. A total of four BMRCs crews were observed during that time. The time/motion measurements taken indicated an average of 327 pick-ups/crew-hr (based on a time weighted average). This is about 11% higher than the estimated average summer productivity shown on Table 2.2. Considering the relatively short period over which the time/motion study was done, it is believed that these measurements agree quite well with the productivity analysis presented here.

EVALUATION OF COLLECTION SYSTEM PERFORMANCE

Method of Evaluation

The relative productivity of a given refuse collection system can be estimated by comparing its productivity with the productivities of other operating systems (assuming a constant level of service). This approach was used in this study.

In 1975 the U.S. EPA published the results of a detailed study of 11 municipal collection systems ("Residential Collection Systems", EPA/530/SW-97c.1, March, 1975). The study monitored day to day operation of the systems for a 1-year period and evaluated year-round productivity. The following quotation from the summary section of the study report sums up the goals and achievements of the study. "A concerted effort was made to select only highly productive systems for this study. Also, the most productive four routes of each system were selected for study. The study data, then, represent reasonable productivity targets for similar systems. It is expected that this information will give residential solid waste collection managers everywhere a valuable tool for appraising the productivity and cost efficiency of their operations." This study represents one of the best efforts to date of residential solid waste collection productivity analysis.

Three of the systems studied by the EPA are comparable to the BMRCS on a level of service basis. These systems will be referred to as the Comparison Systems and shall be identified as systems A, B and C. The basic system characteristics and operating parameters for the Comparison Systems and the BMRCS are presented in Table 2.4. The systems all offer the same basic level of service: twice per week collection with curb/alley placement. The systems will not be directly comparable on a per crew productivity basis because they all use different crew sizes. However, since the tasks of the walkers are similar for all the systems, they will be directly comparable on a per walker productivity basis. Also, because the basic level of service is constant, the Comparison Systems will be directly comparable with the BMRCS on a cost efficiency basis. It can be seen from Table 2.4 that the operating parameters for the systems (operating agency, incentive system, containerization, unionization) are the same except for equipment types and collection methodology. However, in general it can be said that the equipment types are compatible with the crew sizes, and each system's collection methodology is compatible with its equipment type. The information necessary to determine if other similarities exist (topography, weights collected, etc.) is not presently available.

Evaluation of Productivity

Several measures of productivity for the BMRCS and the Comparison Systems (A,B,C) are given in Table 2.5. The development of the BMRCS productivity estimate was previously discussed. The productivity for the Comparison Systems was measured during the 1-year EPA study.

As might be expected, the per crew productivity shown in Table 2.5 increases with increasing crew size. This occurrence is illustrated in Figure 2.1. Because BMRCS has the greatest number of persons per crew it has the highest per crew productivity. On the other hand, the per walker productivity for the BMRCS is similar to that of the other systems and is, in fact, very close to the average of the other three.

TABLE 2.4
OPERATING PARAMETERS FOR BIRMINGHAM
AND COMPARISON SYSTEMS

System(1)	Operating Agency	Crew(2) Size	Incentive System	Equipment(3) Type	Collection Frequency	Collection(4) Methodology	Storage(5) Container	Container(6) Placement	Worker Unionization
Birmingham	Public	4	Task	Rear load	2/wk	both sides	BBC	C/A	yes
A	Public	1	Task	Side load	2/wk	one side	BBC	C/A	yes
B	Public	2	Task	Side load	2/wk	one side	BBC	C/A	yes
C	Public	3	Task	Rear load	2/wk	both sides	BBC	C/A	yes

(1) Data for systems A, B and C taken from "Residential Collection Systems, Volume 1", EPA/530/SU-97c-1, U.S. EPA, 1974.

(2) Includes drivers and walkers.

(3) Packer capacity varies.

(4) Both sides - both sides of street collected on one pass; one side - one side of street collected per pass (2-pass system).

(5) BBC - bags and cans.

(6) C/A - curb or alley.

TABLE 2.5
PRODUCTIVITY OF BMRCs AND COMPARISON SYSTEMS

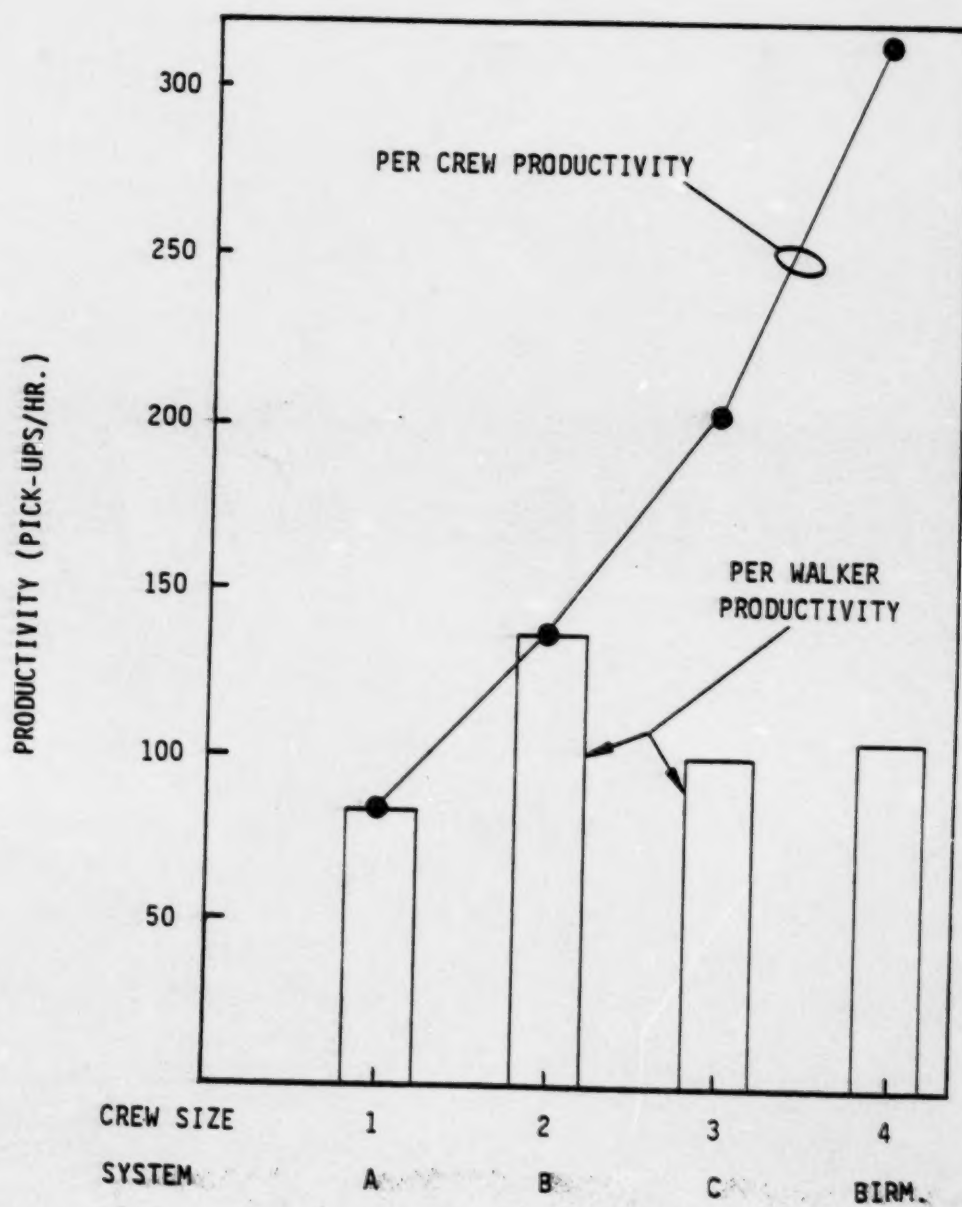
<u>System</u> (1)	<u>PRODUCTIVITY</u>		
	Pick-ups made per on-route hour		
	<u>per crew</u>	<u>per crew-person</u>	<u>per walker</u>
BMRCs(2)	311	78	104
A(3)	84	84	84
B(3)	138	69	138
C(3)	201	67	100

(1) See Table 2.4 for system definition.

(2) Average for all Birmingham districts. See Table 2.2 for Birmingham productivity.

(3) Measured during 1-year EPA study. Driver is also walker for System A.

PRODUCTIVITY FOR BIRMINGHAM AND COMPARISON SYSTEMS



Based on the fact that the Comparison Systems were selected to be the four most productive routes of highly productive systems and assuming that this objective was achieved, the following conclusion is offered:

- o The garbage collection of the BMRCs is highly productive on both a per crew and per walker basis.

Evaluation of Cost Efficiency

Productivity measurements are helpful tools for evaluating how well a given municipal refuse collection system is working. In general, productivity and cost efficiency are directly related. However, there are instances where this is not so (usually when expensive equipment is being under utilized). The basic consideration must be the economic efficiency of the system. The objective of this section is to evaluate the cost efficiency of the Birmingham system and compare it to other highly productive operating refuse collection systems.

A basic measurement of the cost efficiency of a given refuse collection system is the cost of serving each home weekly (\$/home-week). Using such a parameter it is possible to compare systems whose total costs are completely different due to the sizes of the areas served. Cost efficiency was measured as follows:

1. Determine the average system per crew productivity (P).
2. Determine the average productive time worked per week (T).
3. Calculate the average number of homes serviced per week (NH).

$$NH = 1/2 P \times T$$

(note that the 1/2 factor accounts for twice per week collection from each home.)

4. Determine the total per crew weekly cost.

- o Personnel Cost (PC)
 - wages
 - fringe benefits
 - personnel overhead

o Equipment Cost (EC)

- capital cost
- debt service
- maintenance
- fuel and oil
- replacement due to down time
- loss of productivity due to equipment age

5. Calculate the system cost efficiency (CE).

$$CE = (PC + EC)/NH$$

The cost efficiencies of the BMRCs and the Comparison Systems (A, B, C) were calculated. The cost efficiency of each system is comparable because the same cost basis was used. The costs are based on the wages and equipment costs of the BMRCs.

Labor Rates - Drivers \$6.73/hr

Walkers \$4.35/hr

Fringe Benefits - 30%

Personnel Overhead - 9%

Equipment Costs - Rear Loader \$19,300/year

Side Loader \$20,100/year

(see life cycle cost estimates in Chapter 4).

Also, the average on-route time for the BMRCs was applied to all of the systems. It was thus determined how many homes each system could serve working at its own productivity rate for the same number of hours.

The results of the cost efficiency analysis and comparison are shown in Table 2.6. It was found that the BMRCs was the most cost efficient of the systems analyzed. In general, the cost efficiency of the systems increased as the number of crew members increased. The reason for this stems from the fact that the cost of the packer vehicle (and driver if he does not collect) is, in one sense, an overhead or fixed cost. As the number of personnel increase the percentage of the total crew cost which is composed of the packer overhead decreases. If the crew productivity can be proportionally increased by the addition of more walkers, the crew's cost efficiency

TABLE 2.6
COST EFFICIENCY OF BMRCS AND COMPARISON SYSTEMS

System	Per-Crew Productivity(1) (pick-up/crew-hr)	Per-Crew Cost (\$/wk)(2)		Average Productive Time(3) (hr/day)	Average (4) Homes Served Per Week	Per Home Collection Cost(5) (\$/wk) (\$/yr)			
		Labor	Equipment Total						
BMRCS	311	943	294	1237	4.3	17.4	2706	0.46	23.8
A	84	321	308	629	4.3	17.4	731	0.86	44.7
B	138	528	308	836	4.3	17.4	1201	0.70	36.2
C	201	735	294	1029	4.3	17.4	1749	0.59	30.6

(1) Productivity for BMRCS based on total time measurements and non-productive time estimates. Productivity for Systems A, B and C measured in 1-year EPA study.

(2) Costs have been normalized to a comparable basis. Costs are for 4 working days/week.

(3) Actual productive (on-route) time for Comparison Systems were 4.9 hr/day for A, 4.1 hr/day for B and 4.4 hr/day for C. Birmingham productive time is applied to all systems for comparison purposes.

(4) Two pick-ups per week for each home.

(5) Cost for garbage collection only. Does not include Wednesday trash pick-up or landfill disposal cost.

can also be increased. However, there are limits. For any given system and method of operation, there is a point where the incremental increase in productivity due to addition of more walkers will begin to diminish. Beyond this point, a loss of cost efficiency will begin to occur if more walkers are added. In some refuse collection systems, it has been found that a 2-walker crew is more cost effective than a 3-walker crew. This, however, does not appear to be the case with the BMRCs. For further discussion concerning crew size see Chapter 3.

In conclusion it can be said that:

- o The BMRCs is highly cost efficient when compared to other systems offering the same nominal level of service. Collection is presently accomplished with a lower per home served unit cost than other productive systems which offer the same nominal level of service.

TABLE 3.3

PRODUCTIVITY FOR TWO-WALKER CREWS

<u>System</u>	<u>Crew Size</u>	<u>Collection Frequency</u>	<u>Incentive System</u>	<u>Refuse Placement</u>	<u>Productivity (pick-up/crew-hr)</u>
Birmingham w/ 2-walker crews	3	2/wk	task	curb/alley	208(1)
Comparison System C(2)	3	2/wk	task	curb/alley	201
Dade County, Florida(3)	3	2/wk	task	curb	128
Phoenix, Arizona(3)	3	2/wk	task	alley	103

(1) Estimated based on productivity of current 4-person crews.

(2) See Chapter 3 for Comparison System information.

(3) Based on unreferenced data provided by John Thompson, U.S. EPA.

CHAPTER 3

RESIDENTIAL REFUSE COLLECTION
SYSTEM COST REDUCTION ALTERNATIVES

CHAPTER 3
RESIDENTIAL REFUSE COLLECTION
SYSTEM COST REDUCTION ALTERNATIVES

Prior to the beginning of this study, the Birmingham Department of Streets and Sanitation (BDS&S) developed four different plans which could help to reduce the total cost of garbage and trash collection for the City of Birmingham. One of the objectives of this study is to review these plans with respect to their economic and technical feasibility. In this chapter the plans are discussed and evaluated. A discussion of alternate cost savings concepts is also presented.

COST REDUCTION PLANS DEVELOPED BY THE BDS&S

Description of Plans

Plan I involves reducing the total number of crews in the Birmingham Municipal Refuse Collection System (BMRCS) from 33 to 29. One crew would be removed from each district, and the routes of the remaining crews would be adjusted to provide full district coverage. The cost savings associated with this plan would come from the elimination of expenses for 16 workers (12 walkers, 4 drivers) and 4 packer vehicles.

If Plan II is put into effect, the total number of crews operated by the BMRCS will stay at the present number of 33. Cost savings would be realized by reducing each crew's size to 3 persons; a reduction of 1 walker per crew. This plan would result in a savings of the personnel costs of 33 walkers. No equipment cost reductions would be incurred.

Plan III involves a reduction in level of service. This plan consists of changing from twice per week service to once per week

service. The BDS&S estimates that this service reduction would allow the elimination of 8 refuse collection crews. The districts would be rerouted to provide complete coverage. The resulting cost saving would be the expenses for 24 walkers, 8 drivers and 8 packers vehicles.

There are certain residential areas of Birmingham where alleys are present. Plan IV calls for placing 300-gallon containers in these areas and collecting the refuse with one-person crews using mechanically loading type vehicles. Each container could serve up to four households. It has been estimated by the BDS&S that, if this plan were to be put into effect in all applicable areas, it could replace about four 4-person crews. Plan IV could be used in conjunction with any of the three plans previously mentioned. Plan IV would eliminate the personnel costs of 12 walkers; the drivers from the four replaced crews would be used to operate the one-man vehicles. The plan would eliminate 4 packer vehicles but would require the purchase of 5 (4 duty and 1 spare) mechanically loading vehicles and about 3,500 containers.

Since the commencement of this study, the BDS&S has made a tentative decision on changes for the refuse collection program. A final decision will be made after the results of the Technical Assistance Study have been reviewed. The tentative plan is to adopt Plan I (previously described) with one major change. The work week will be changed from 5 days (8 hours per day) to 4 days (10 hours per day). This means that the trash and clean-up activities now being done on Wednesday will be performed along with regular garbage collection during the other four weekdays. The BDS&S is also considering implementation of 2 one-man crews; (a partial adoption of Plan IV) along with the other changes of the tentative plan. The decision concerning one-man crews, however, has not been finalized as of this writing.

ECONOMIC FEASIBILITY OF PLANS

When the BDS&S developed the four cost reduction plans (I through IV), estimates were made of how much money would be saved. These estimates were reviewed in detail as part of this study.

The estimates were found to be accurate and reasonable except for the fact that the estimate of labor costs did not allow for absenteeism due to vacation and sick leave. During paid leave a collection worker must be replaced resulting in additional labor costs. One way of looking at it is that for every 17 full time employees one additional employee is required just for replacement during vacation and sick leave (assuming an average of 3 wk/yr per employee absenteeism). Table 3.1 shows the original cost savings estimates as well as estimates which have been adjusted for the discrepancy. In correcting the estimates it was assumed that each worker would be absent for two weeks of vacation and one week of sick leave per year. Adjustment for absenteeism resulted in an increase in the estimated cost savings for all four plans.

TECHNICAL FEASIBILITY OF PLANS

Plan I

The net impact of Plan I on the BMRCs will be that the same amount of work which is now being performed each day will have to be done with fewer crews. To accomplish this the average amount of work done by each crew per day must increase. There are only two ways in which a given work force (in this case the collection crew) can produce more work:

- o Work at a more productive rate
- o Work for a longer period of time

In the previous chapter the garbage collection productivity of the BMRCs was evaluated. It was found that the BMRCs crews and individual crew members, on the average, are highly productive (when compared to other workers doing similar jobs). Although some increase in individual productivity can always be achieved it is not reasonable to expect a dramatic increase in this case. It is probable that the increased per day work load will have to be compensated for by longer working hours. Table 3.2 shows estimates of the winter, summer and

TABLE 3.1
COST REDUCTION ESTIMATES

<u>Estimated Cost Reduction Over Present System (\$/year)(1)</u>		
	BDS&S Original (2)	Estimate Adjusted
	<u>Estimate</u>	<u>for Absenteeism(3)</u>
Plan I	260,100	272,400
Plan II	388,200	410,600
Plan III	520,200	544,900
Plan IV	42,100	47,000(4)
Tentative Plan	-	272,400(5)
Tentative Plan with One- person crews	-	306,500(5) (6)

(1) All estimates are based on certain assumptions which were made by the BDS&S. The savings could vary significantly based on assumptions made concerning equipment life, container life, etc.

(2) Estimates made by BDS&S using January 2, 1980 cost figures.

(3) Assume: 2 weeks per year per person vacation
1 week per year per person sick leave

(4) Since the BDS&S estimates were made it has been proposed to eliminate the use of 400, 90-gallon containers from the original plan. This has added about \$4000/year to the savings for Plan IV. This savings results from use of 4 one-person crews only. Additional savings could be derived by applying cost savings concepts similar to other plans with the remaining full crews.

(5) These plans had not been developed when BDS&S made original cost estimates.

(6) Does not include cost for any equipment back-up system. This estimate allows for 2 one-person crews. As many as 2 more could be added in the future.

TABLE 3.2
ESTIMATED TASK TIMES FOR PRESENT SYSTEM
AND PLAN I SYSTEM

	<u>Average Per Crew Task Time (hr/day)(1)</u>		<u>Increase (%)</u>
	<u>Present System(2)</u>	<u>Plan I System(3)</u>	
Year Average	6.1	6.9	13
Winter Months	5.6	6.4	14
Summer Months	6.6	7.4	12

(1) Includes all daily activities for garbage collection. Based on 5-day work week with trash collection on Wednesday.

(2) Based on analysis of data discussed in Chapter 2.

(3) Assuming per crew productivity same as present system.

year-round average task times for the present collection system (note task time includes all garbage collection day activities). Also shown are estimates of the task times which would be required if the Plan I system is instituted. The Plan I task times are estimated assuming the same per crew productivity as the present system. It is estimated that, on the average, the BMRCS collection workers would be required to work about 13% longer on garbage collection days.

At present, the BMRCS is operated on a task incentive program. Workers are given a specific group of tasks which must be accomplished each day. The workers are allowed to leave work when these tasks have been satisfactorily completed but are paid for a full 8-hour day. The individual worker is given the incentive to work efficiently and productively so he/she can leave work early without losing any pay. Task incentive programs have been used with many refuse collection systems and have helped to improve system productivity in almost all cases. However, for a task incentive program to succeed, the individual worker must be rewarded for working productively; he/she must be able to finish the required task in a significantly shorter time than he/she is being paid for. As an example, a worker will not be induced to give 100% all day long if the only reward is 10 minutes off at the end of the day. It has been estimated that the average annual garbage collection day task time will be about 6.9 hours per day per crew if Plan I is put into effect with a 5-day work week. This corresponds to about 86% of an 8-hour day. Whether or not the task incentive program will work with Plan I as well as it is working with the current system is not known at present. However, there is a strong possibility that continuing crew reductions could lead to chronic employee dissatisfaction due to increasing task times. A variety of problems such as sloppy work and/or an excessive employee overturn rate could occur. It is not known if the increase in task time that would result from Plan I would cause significant problems in this area.

It is concluded that Plan I operated on a 5-day work week is technically feasible. However, there is a risk of incurring employee

dissatisfaction and the potential for success of further crew reductions of this nature might be questionable unless other employee incentives are provided.

Plan II

The probable impact of Plan II would be to lower the productivity of the individual BMRCs crews. At present the BMRCs 4-person crews are making about 311 pick-ups per crew hour or about 104 per walker per hour (year-round average). If 3-person crews were used the reduction in manpower would probably result in a lower net per crew productivity. It would be necessary to conduct field tests of 3-person crews in Birmingham to accurately predict the impact on productivity that this reduction in manpower would cause. In Table 3.3 information is presented on three collection systems that utilize 3-person crews, collect twice per week from the curb and/or alley, and work on a task incentive program. As shown in this table, the productivity for the three systems (other than the BMRCs) range from 103 to 201 pick-ups/crew-hr. Table 3.3 also presents an estimate of productivity for the BMRCs using a 3-person crew size. This estimate was made assuming that the present per walker productivity (104 pick-ups/walker-hr) would be maintained with 2-walker crews resulting in 208 pick-ups/crew-hr. This estimated productivity is similar to that measured for Comparison System C but is considerably higher than the measured productivities of the other two systems. Though it is possible that the 3-person crew productivity of the BMRCs could exceed 208 pick-ups/crew-hr, the information for the three 3-person crew systems indicates that it is not reasonable to expect a drastically higher productivity on a long-term, system-wide average. Therefore, for the purposes of this report it is assumed that the average productivity for the BMRCs will be about 208 pick-ups/crew-hr if the collection crew manpower is reduced by one person per crew.

Plan II would not involve a change in the areas of responsibility for the BMRCs crews (i.e. same routes would be used as present system). Thus, each crew, working with 3 persons at a lower net productivity, would need to work longer each day to do its job. It is estimated that at an average productivity of 208 pick-ups per crew per hour it would

TABLE 2.2
BMRCS GARBAGE COLLECTION PRODUCTIVITY

District	Study (1) Period	Number of Crews per District	Average Total Weekly Time(2) hr/crew	Weekly Non-Productive Time(3) (crew-hr/district)	Weekly Productive(4) Time (crew-hr/district)	Pick-up Locations(5) Per District	Productivity (pick-up/crew-hr)
South Side	Summer Winter	8 8	26.9 21.7	215 174	159 129	19,500 19,500	245 302
Eastley	Summer Winter	9 9	26.4 22.8	238 205	166 151	24,500 24,500	275 325
East End	Summer Winter	8 8	25.3 22.4	202 179	143 131	21,000 21,000	294 321
North Birmingham	Summer Winter	8 8	25.6 22.7	205 182	139 134	24,200 24,200	348 361

AVERAGE PRODUCTIVITY

Summer	-	295	pick-up/crew-hr
Winter	-	327	pick-up/crew-hr
Year-round	-	311	pick-up/crew-hr

- (1) Summer Period - June-July, 1979. Winter Period - January-February, 1980
- (2) Total from time trucks leave yard until collection is finished and vehicles are washed. Taken from daily log sheets. 4 day/48 garbage collection only.
- (3) Includes travel to route, travel to and from landfill and vehicle wash time. Estimated with help of BMRCS personnel. 4 day/48 garbage collection only.
- (4) On route time only. 4 day/wk garbage collection only.
- (5) Based on residence count by district for man.
- (6) 2 pick-ups per home per week.

TABLE 2.3
SUMMARY OF PRODUCTIVITY AFFECTING FACTORS FOR BIRMINGHAM

<u>Consideration</u>	<u>General Trend</u>	<u>General Statement Concerning Birmingham(1)</u>	<u>Supported by(2)</u> Data	<u>Marginal(2)</u>	<u>Not Supported(2)</u> by Data
Population density	Lower population density means greater spacing between homes. Tends to reduce productivity.	Ensley and North Birmingham districts generally most densely populated.	X		
Affluency	Higher affluency tends to reduce productivity by: (1) Higher per capita refuse production (2) Lower population density.	East End district is most affluent		X	
Topography	Collection productivity generally lower in hilly areas.	South Side district is most hilly part of town			X
One-way Streets	One-way streets makes efficient routing difficult and tend to reduce productivity.	Not significant in Birmingham residential areas			

(1) General statements based on information provided by BMS&S personnel

(2) See Table 2.2 for productivities of districts.

require an average of about 6.5 on-route hours per day for each crew to complete its route (year-round basis). If the necessary non-productivity time (travel, landfill, vehicle washing, etc.) is added in, the resulting year-round average daily task time is estimated to be about 8.7 hours. Consequently, the task system would no longer hold any incentive for the collection workers, if the average daily task time exceeded 8 hours. For a task incentive program to succeed it must be possible for the employees to obtain a reward for working productively (i.e., 8 hours pay for less than 8 hours work). It is not reasonable to ask an employee to work for 8 hours pay when he/she cannot finish his/her task in 8 hours.

Based on the probability that Plan II, as specifically stated by the BDS&S, would result in excessive task time for the BMRS crews, it is concluded that it has a relatively low technical potential for success. However, it is possible that the concept of 3-person crews might be used for successful cost saving system changes with the BMRCS. This possibility will be investigated later in this chapter.

Plan III

Plan III involves a reduction in level of service to once per week collection. It has been estimated by the BDS&S that 8 crews could be eliminated; 24% of the present 33 crew work force. This is an entirely reasonable estimate and, in fact, might be on the conservative side. A general rule which works well in most cases is that 33% of the work force can be eliminated by reducing the level of service from twice per week to once per week collection. It must be remembered, however, that the cost savings from Plan III would not be due to an increase in cost efficiency; they would be due to a reduction in service being provided to the public.

One problem which could occur with Plan III is that a public health hazard and/or nuisance might be created. Standing household refuse provides a good environment for the breeding of flies and other disease spreading pests. The potential for this problem is partially dependent upon the climate. In some hot and humid places, household refuse is disposed of more than once per week to prevent a

fly problem, rather than to provide more convenient service. Considering the climate of Birmingham, it is likely that once per week collection would have public health and/or nuisance impacts; at least during summer months.

Based on the possible health impacts it is concluded that Plan III has a relatively low probability for successful use with the BMRCs on a year-round basis. It would be possible to offer once per week collection during winter months and twice per week collection during summer months. However, the seasonal fluctuation in labor requirements could cause difficulties which should be carefully considered before implementing such a plan.

Plan IV

Plan IV involves using one-person crews and special mechanically loading packers in as many as eight routes in Birmingham where alleys exist. Large containers are placed in the alleys and each is used by more than one family. Systems similar to this have been used successfully in other cities. However, there are some disadvantages with this type system.

- o The containers used are relatively expensive (the BDS&S estimates \$150 for 300 gallon containers) and are subject to vandalism and theft. It is estimated that a realistic economic life for a full set of containers (allowing for replacement due to deterioration and loss) is between five and seven years.
- o The containers are large and cannot be practically loaded by hand when full. If a truck breaks down, it must be replaced with one that has the equipment necessary to load the containers, or an alternate method of loading must be used. In Birmingham, this would require that at least one standby truck or system is available (expense for one standby truck has been included in cost savings estimates). It would not be advisable to institute Plan IV without an effective back-up system.
- o The fact that more than one family uses each container

could leave some question as to who has responsibility for cleaning around the container. If none of the users clean up then either the alley will become messy and dangerous or the collection worker will have to police the area. If the collector spends time doing this, the efficiency of the system is reduced.

- o With Plan IV, individual collection workers will be working the routes alone. From a safety standpoint, it is usually beneficial to have collection personnel working in groups of more than one.

The cost savings with Plan IV were estimated by the BDS&S to be about \$47,000/year (if absenteeism is included). This figure would increase to about \$51,000/year if no 90-gallon containers are purchased (see note on Table 3.1). However, depending on assumptions that are made concerning equipment and container life, it can be estimated that the savings could range from \$8,000 and \$64,000/year. These savings would result only from the use of the four one-person crews. Total system savings could be increased by applying the cost saving concepts (such as the ones the other plans are based on) to the remaining conventional crews. The incremental savings of a system using one person crews would also be higher if the cost of maintaining a stand-by vehicle could be applied to a larger number of crews (8 or 10 rather than 4).

Based on the potential problems (administrative and other) associated with this plan and the marginal cost savings which would result it is concluded that the potential for success of Plan IV is questionable.

Tentative Plan

As previously mentioned, the BDS&S has made a tentative decision concerning changes for the residential refuse collection system. It has tentatively been decided to institute Plan I with a 4-day work week (10 hr/ day). This course of action shall henceforth be referred to as the Tentative Plan. The trash collection and clean up which is now being done on Wednesday would be done along with

garbage collection on Monday, Tuesday, Thursday and Friday if the Tentative Plan is instituted. From a technical point of view this plan appears to be feasible. There should be no problem combining the materials since, at present, the same packer vehicles are used to haul both trash and garbage.

Table 3.4 shows task time estimates for the present system, Plan I, and the Tentative Plan. Based on the summer and winter study periods discussed in Chapter 2, it is estimated that, on a year-round, system-wide average, each BMRCs crew works about 6.1 hours on garbage collection days (Monday, Tuesday, Thursday and Friday) and about 5.3 hours on trash collection and clean-up day (Wednesday). If Plan I is instituted on a 5 workday per week basis, it is estimated that each crew will spend about 6.9 hours on garbage collection days and approximately 6.0 hours on trash and clean-up day. The estimate for the entire work week in this case is 34 hours per crew. It is not possible to accurately estimate the average task time if the Tentative Plan is put into effect. On the one hand, trash will be picked up along with garbage so the per day task time will probably be longer than if garbage was being collected alone. However, as each route will be traveled only twice per week with the Tentative Plan rather than three times per week (as it would be with a 5-day work week), the total weekly task time is bound to be less. It is only possible to estimate that the year-round average per crew daily task time will be between 6.9 and 8.3 hours with the average weekly task time being between 28 and 33 hours per crew. It is believed that use of a 4-day work week along with the crew reductions (Tentative Plan) is more desirable than use of a 5-day work week (Plan I) and represents a logical approach to cost reducing changes for the BMRCs. Collection of trash and garbage concurrently will be more efficient than separate collection. Also, because each route will be traveled only twice per week rather than three times per week there should also be a favorable impact on equipment operation and maintenance costs.

TABLE 3.4

ESTIMATED TASK TIMES FOR SYSTEM ALTERNATIVES

	Average Per Crew Task Time (1)	
	<u>hour/day</u>	<u>hour/week</u>
<u>Present System</u>		
Garbage Days(2)	6.1	24.4
Trash Day(3)	5.3	<u>5.3</u>
Total		29.7
 <u>Plan I - 5-Day Week</u>		
Garbage Days(2)	6.9	27.6
Trash Day(3)	6.0	<u>6.0</u>
Total		33.6
 <u>Tentative Plan(4)</u>		
Garbage and Trash Days(2)	6.9-8.3	27.6-33.2

(1) Estimated year-round average. Estimates made from summer and winter study periods discussed in Chapter 2.

(2) 4 days per week; Monday, Tuesday, Thursday, Friday.

(3) 1 day per week; Wednesday.

(4) Plan I using a 4-day work week.

Tentative Plan With One Person Crews

As previously mentioned, the BDS&S is considering the use of one-person crews (and the appropriate special vehicles and containers) on four routes in conjunction with the changes being referred to as the Tentative Plan (could be expanded to as many as eight routes in the future). The idea is that mechanically loading trucks would be purchased for use on these routes and that the residents which are being provided with the one-person crew service would be billed separately for the container costs.

An estimate of the cost savings for using four one-person crews has been previously presented. If only two mechanically loading packer vehicles are purchased for use on the four one-person routes the total annual cost savings would be about \$31,000 (over service with regular crews and vehicles). However, this would not allow for a standby vehicle. As previously discussed, the larger containers cannot practically be emptied by hand when full. If one of the vehicles were to break down, there could be a temporary difficulty in providing collection service. A standby vehicle could be purchased to back-up the two duty vehicles. However, this would reduce the total annual savings to about \$16,000.

There may be some measures which can be taken on the occasion of equipment failure to maintain service to the one-person crew routes. For example it might be possible to secure a contract with an equipment vendor to rent a mechanically loading packer vehicle when one of the City's vehicles is temporarily out of service. Another alternative might be to use a different type of equipment for dumping the large containers into a conventional rear loaded packer vehicle (e.g., forklift). It might also be possible to empty the large containers into a rear load packer with the aid of a power winch (similar to those used to empty rear loaded type trash bins). If no other method was available it would be possible to have one truck doing "double duty". This would involve having one crew run its route after the other one has finished with the truck for the day. This idea has

merit but could lead to employee dissatisfaction if it was used excessively. Before deciding to institute any one-person collection crews the BDS&S should consider what type of equipment back-up systems and/or methods are available. The cost impact of the most practical equipment back-up system should be taken into account (note that the \$31,000/year cost savings estimate does not allow for any back-up system costs).

As previously stated, the idea of having the residents who are serviced by the one-person crews pay the costs for the special containers has been presented. This would reduce the necessary operating budget for the collection system by about \$37,000 annually (in addition to the previously mentioned \$31,000/year savings which could be derived from the one-person crew system). There is a definite question as to whether or not it is equitable to charge a limited segment of the public more money than the other residents for the same basic service. Also the \$37,000 per year cannot be considered a collection system cost savings. The citizens of Birmingham pay indirectly for refuse collection. Invoicing a portion of the population for use of the containers would only increase the total amount of money being paid by the public for refuse collection. This does not represent a cost savings due to improved efficiency or increased productivity.

It is believed that there are numerous problems that could be associated with using one-person crews and mechanically loading vehicles for refuse collection in Birmingham. Some of these problems have been presented in this section as well as during the discussion of the Plan IV alternative. It has been shown that the potential cost savings from this type of operation are relatively small when compared to the total amount of money being spent for refuse collection in Birmingham. Due to these facts, it is concluded that, in this case, the potential for economic and technical success of this type of system change is questionable.

TABLE 3.5

FEASIBILITY SUMMARY FOR COST REDUCING PLANS

<u>Cost Reducing Plan(1)</u>	Estimated Relative Potential for Successful Application to Birmingham System (2)		
	<u>Good</u>	<u>Questionable</u>	<u>Poor</u>
Plan I	X		
Plan II			X
Plan III			X
Plan IV		X	
Tentative Plan	X		
Tentative Plan with One-Person Crews		X	

(1) See previous sections of this chapter for plan descriptions.

(2) Estimate of economic and/or technical potential of success.

Summary

A number of cost saving plans have been developed by the BDS&S for the BMRCS. These plans have been presented and discussed in the previous sections of this chapter. The relative merits and possible cost savings of each plan have been considered. Based on these considerations, each plan has been given a qualitative rating according to its estimated relative potential for success. Table 3.5 lists the cost reduction plans in question and indicates how each has been rated in reference to its potential for economic and technical success in Birmingham.

ALTERNATIVE COST SAVING MEASURES

The plans which have been developed by the BDS&S for reducing refuse collection costs in Birmingham have been previously discussed. The objective of this section is to present and discuss some alternative concepts which might be used to further reduce collection system costs.

Additional Crew Reductions

As previously discussed, Plan I and the Tentative Plan call for reduction of the total number of BMRCS crews from 33 to 29. This should reduce the system's cost by about \$272,000 per year. It is possible that further crew reductions could be made to increase this savings. Any further crew reductions would, again, increase the average daily work load of each crew. This would have to be compensated for by an increase in the per crew productivity and/or longer working hours. The productivity of the BMRCS was analyzed in Chapter 2. The analysis indicated that the system, at present, is highly productive when compared to other efficiently operating systems. Although personnel productivity can always be increased, it is not likely that a drastic improvement can be made in this area with the BMRCS. Thus, it is likely that any further labor force reductions would result in longer average daily working hours. The task incen-

tive program of the BMRCs appears to be working well and care should be taken not to "overload" it. An overloaded task system could result in sloppy work and/or chronic employee dissatisfaction. Chronic employee dissatisfaction could lead to an excessive turn over rate which would have a number of negative effects. Care should be taken if any further labor force reductions are considered.

Utilization of 3-Person Crews

It was concluded earlier in this chapter that use of 3-person crews (one driver, two walkers) as outlined under Plan II has a low potential for success with the BMRCs. This conclusion was based on the fact that if 33 3-person crews were used to perform collections in Birmingham the per crew task times could become excessive. However, it was also mentioned that there may be a mode of operation for the BMRCs where 3-person crews could be used to result in cost savings for the system.

Two comparative analyses have been done to determine the cost efficiency of 3-person crews with the BMRCs.

Comparison 1:

The present BMRCs versus an equivalent 3-person crew system.

Comparison 2:

The BMRCs with adoption of Plan I versus an equivalent 3-person crew system.

The term "equivalent 3-person crew system" is used here to represent the number of 3-person crews that would be required to accomplish the same amount of work with each crew spending the same on-route time each day as the corresponding 4-person crew.

For the purposes of this analysis, it is assumed that the productivity for 3-person BMRCs crews would be about 208 pick-ups/crew-hr (see discussion under Plan II of this chapter). Given the average productivity and weekly on-route time, it is possible to calculate the required number of 3-person crews for an equivalent system. The per crew weekly on-route times are 17.4 hours and 19.9 hours for Comparisons 1 and 2 respectively. The calculation to determine the

equivalent 3-person crew systems is outlined in Table 3.6. It is estimated that it would require about 49 3-person crews working at an average rate of 208 pick-ups/crew-hr for 17.4 on-route hr/week to perform residential garbage collection in Birmingham (Comparison 1). It was also estimated that 43 3-person crews could perform the same job working at the same rate if the average on-route time was 19.9 on-route hr/week (Comparison 2).

Cost estimates for the systems involved in Comparisons 1 and 2 are given in Tables 3.7 and 3.8 respectively. It can be seen that in both cases the equivalent 3-person crew systems cost considerably more to operate on an annual basis than either of the 4-person crew systems (about 24% more in both cases).

The comparison which was previously discussed is highly dependent upon one major assumption; the per crew productivity. Though it is believed that the figure used (208 pick-up/crew-hr) is a reasonable estimate of the maximum obtainable long-term average for three person BMRCs crews, this may not be accurate. It may be that 3-person BMRCs crews could exceed this productivity rate. It is possible to mathematically show that for 3-person crews to become economically competitive with 4-person crews in this case the per crew productivity would have to be about 258 pick-ups/crew/hr (applies to both comparison modes previously mentioned). For this to occur, the average per walker productivity would have to increase to about 129 pick-ups/walker-hr; an increase of 24% over the present 4-person crew per walker productivity. For 3-person crews to become more cost effective than 4-person crews it would be necessary to achieve an average per crew productivity in excess of 258 pick-ups/crew-hr and an average per walker productivity in excess of 129 pick-ups/walker-hr.

In many cases it has been found that 3-person crews are more economical to operate than 4-person crews. This normally stems from the fact that the third walker (fourth person on the crew) is not fully utilized and/or slows down the other walkers by crowding the working area behind the packer. This can reduce the net pro-

TABLE 3.6

DETERMINATION OF EQUIVALENT 3-PERSON CREW SYSTEMS

A. Estimated productivity ⁽¹⁾ for 3-person crews	208 pick-up/crew-hr
B. Required number of pick-ups ⁽²⁾ per week	178,400 pick-up/wk
Required on-route time (B/A) ⁽³⁾	858 crew-hr/wk
Required number of crews if each spends 17.4 hr/wk on- route (858/17.4) ⁽⁴⁾	49 crews
Required number of crews if each spends 19.9 hr/wk on- route (858/19.9) ⁽⁵⁾	43 crews

(1) See discussion of Plan II this chapter.

(2) Two pick-ups/wk for 89,200 homes.

(3) Garbage collection only.

(4) Estimated weekly time spent on-route by BMRCs crews with the present system (Comparison 1).

(5) Estimated weekly time spent on-route by BMRCs crews if Plan I were adopted (Comparison 2).

TABLE 3.7
COST ESTIMATES FOR COMPARISON 1

	Present System (33 4-Person Crews)	3 Person Crew System (49 3-Person Crews)
Labor (1)		
Drivers @ \$6.73/hr	462,000	686,000
Walkers @ \$4.35/hr	896,000	887,000
Total Wages	1,358,000	1,573,000
Fringe benefits (30%)	407,000	472,000
Personnel overhead (10%)	136,000	157,000
Absenteeism (6%)	81,000	94,000
Total Labor Cost	\$1,983,000/yr	\$2,297,000/yr
Equipment (2)		
20-cu yd rear loaders @ \$19,300/yr each	\$ 637,000/yr	\$ 946,000/yr
TOTAL ANNUAL COST	\$2,620,000/yr	\$3,243,000/yr
Unit Cost	\$29.4/home-yr	\$36.4/home-yr

(1) Based on spring, 1980 BMRCS wage rates.

(2) See Chapter 4 for vehicle life cycle costs.

TABLE 3.8
COST ESTIMATES FOR COMPARISON 2

Labor (1)	Plan I System (29 4-Person Crews)	3-Person Crew System (43 3-Person Crews)
Drivers @ \$6.73/hr	406,000	602,000
Walkers @ \$4.35/hr	787,000	778,000
Total Wages	1,193,000	1,380,000
Fringe benefits (30%)	358,000	414,000
Personnel overhead (10%)	119,000	138,000
Absenteeism (6%)	72,000	83,000
Total Labor Cost	\$1,732,000/yr	\$2,015,000/yr
Equipment (2)		
20-cu yd rear loaders @ \$19,300/yr each	\$ 560,000/yr	\$ 830,000/yr
TOTAL ANNUAL COST	\$2,302,000/yr	\$2,845,000/yr
Unit Cost	\$25.8/home-yr	\$31.9/home-yr

(1) Based on spring, 1980 BMRCs wage rates.

(2) See Chapter 4 for vehicle life cycle costs.

ductivity of the entire crew to a point where the per pick-up cost of collection with a 4-person crew is higher than the cost with a 3-person crew. However this does not appear to be the case with the BMRCs. A year-round average on the order of 100 to 110 pick-ups/walker-hr has been found to be a fairly high level of per walker productivity. This is evidenced by the findings of the EPA study which was referenced in Chapter 2. It is possible that in some cases where a 2-person crew is achieving 105 pick-ups/walker-hr (210 pick-ups/crew-hr) that addition of a third walker will not increase the net crew productivity proportionally (i.e. net productivity will be less than $3 \times 105 = 315$ pick-ups/crew-hr). The BMRCs seems to have overcome this barrier. The reason(s) can not be pin-pointed but could lie in the following areas:

- o A high degree of team work within the individual crews.
- o A high level of personnel motivation.
- o Good personnel management.
- o A low level of employee turnover (the BMRCs does have a comparatively good record of personnel longevity).

To determine if the cost effectiveness of the BMRCs crews could, in fact, be improved by a change to 3-person crews would require field testing to measure productivity.

Based on the previous analyses the following conclusions are offered:

- o If the BMRCs were converted to a 3-person crew system it would probably require more than 33 crews to perform the required collections and still maintain a reasonable per crew daily task time.
- o If the BMRCs were converted to a 3-person crew system and the present per walker productivity was maintained (104 pick-up/walker-hr) the resulting per crew productivity would be 208 pick-ups/crew-hr. At this productivity rate a 3-person crew system would be more expensive to operate than the present 4-person crew system.

and quite often the same streets are traveled more than once during a day's collection activity. Although the crews didn't appear to be losing an excessive amount of time due to this occurrence, the vehicles were being driven unnecessary miles. It might be prudent to carefully examine the micro-routing for the entire BMRCs. If the routing scheme can be improved, it is likely that there would be a positive effect on collection vehicle fuel and maintenance costs and labor utilization efficiency.

CHAPTER 4

COST SAVINGS THROUGH ALTERNATE EQUIPMENT TYPE USAGE

CHAPTER 4

COST SAVINGS THROUGH ALTERNATE EQUIPMENT TYPE USAGE

The objective of this chapter is to investigate how the Birmingham Municipal Refuse Collection System (BMRCS) operation costs can be reduced through use of alternate collection equipment types.

PRESENT EQUIPMENT INVENTORY

The present BMRCS equipment inventory was discussed in Chapter 2. The system currently uses two different basic types of collection vehicles; rear load packers with conventional compacting mechanisms (20- and 25-cu yd capacities) and rear load packers with auger type compacting mechanisms (20-cu yd capacity).

Birmingham Department of Streets and Sanitation (BDS&S) personnel have indicated a preference for the auger type packers. The basis of this preference is that they achieve a greater degree of compaction than the units with conventional compacting mechanisms. In one recent weighing of a full auger type packer it was found that the refuse had been compacted to greater than 1000 lb/cu yd. In the past the BDS&S has weighed full conventional packers on several occasions. The average density calculated from these weighings was about 550 lb/cu yd.

One of the positive impacts of achieving higher refuse density in the collection vehicle is that more refuse can be picked-up per load and landfill trips are required less frequently. An estimate of the average number of daily landfill trips being made by the BMRCS crews

has been made with the aid of BDS&S personnel. These estimates are summarized as follows:

- o 20-cu yd Conventional Packers

- Summer Months

- Monday, Tuesday - 3 trips/day

- Thursday, Friday - 1.5 trips/day

- Winter Months

- Monday, Tuesday - 2 trips/day

- Thursday, Friday - 1 trip/day

- o 25-cu yd Conventional Packers

- Year-round average for all garbage collection days - 1.5 trips/day

- o 20-cu yd Auger Type Packers Year-round average for all garbage collection days - 1 trip/day

According to these estimates the crews using the higher compaction auger type vehicles are making quite a few less landfill trips weekly than the crews using conventional packers.

METHOD OF COST REDUCTION

As discussed in Chapter 3, landfill trips cost money in terms of equipment and labor costs. If the total number of required landfill trips for a given collection system can be reduced, there will be a savings in equipment operation and maintenance costs. Also collection workers will be able to spend more time on productive activity (on-route collection). In the case where a task incentive program is being used, a reduction in landfill trips means that the collection workers can spend a higher percentage of their time on-route and can make more pick-ups per day while working the same total number of hours. Thus the per crew daily productivity is increased and it is possible to perform the necessary number of collections with fewer crews and vehicles. This should mean a reduction in total collection system costs.

COST ANALYSIS

A cost comparison was made to determine the impact that use of more high compaction packer vehicles could have on the BMRCs. For illustrative purposes, the BMRCs was considered using 29 crews to perform 4 day per week collection of garbage and trash with the present equipment inventory (the Tentative Plan system discussed in Chapter 3) and will be referred to as System A. For comparison purposes a hypothetical system will be created; System B. All operating parameters for System B will be the same as System A except:

- o System B will use high compaction packer vehicles exclusively and;
- o System B will operate with fewer crews

Note that the comparison will be done assuming System B is using auger type packers. However, any type packer which is economically competitive to the auger packer and can achieve the same high degree of compaction could be used.

Table 4.1 shows an estimate of the annual average number of crew-hours that would be spent weekly on landfill trips with System A. The number of landfill trips shown in Table 4.1 is based on the estimates for the present system which have been previously discussed. Since these estimates were for garbage collection alone it was necessary to add a factor to account for simultaneous collection of garbage and trash. It was assumed that by collecting garbage and trash at the same time that about one more trip per crew per week would be necessary during winter months and that about two more would be required during summer months (note that these additions account for landfill trips now being made on trash collection day; Wednesday). Given the number of landfill trips, the time required to make these trips was calculated assuming that, on a system wide average basis, each requires about 45 minutes (the estimate of per trip time was made by BDS&S personnel). Based on this analysis it is estimated that a total of 180 crew-hr (720 man-hr) would be spent weekly on landfill trips with System A.

TABLE 4.1

ESTIMATE OF TIME SPENT ON LANDFILL TRIPS USING PRESENT
EQUIPMENT INVENTORY (SYSTEM A)

Packer Vehicle Type	Number in Service	No. Landfill Trips Per Week Per Vehicle (1)			Time Spent on Landfill Trips (crew-hr/wk) (2)	
		Winter	Summer	Year-Round Average	Per Vehicle	All Vehicles
20-cu yd rear load (conventional)	19	7	11	9	6.8	129
25-cu yd rear load (conventional)	6	7	8	7.5	5.6	34
20-cy yd rear load (auger type)	4	5	6	5.5	4.1	17
					Total = 180	

- (1) Estimated. At present it is not known how collection of garbage and trash simultaneously will impact the number of required landfill trips.
- (2) Estimated assuming system wide average of 45 min/trip.

Since System B uses high compaction packer vehicles exclusively, the per crew time spent on landfill trips will be less than System A. Based on the considerations discussed in the previous paragraph, it is estimated that the year-round average time for landfill trips with System B is about 4.1 hours per crew per week (see Table 4.1).

Table 4.2 shows a break down of weekly time utilization for Systems A and B. As previously stated, System A uses 29 crews; each spending an average of 6.9 hr/day on all garbage and trash collection tasks (a total of 928 crew-hr/wk). However, System B has been set up to use 26 crews; three less than System A. As with System A, each System B crew spends a total of 6.9 hr/day working. However, because of the reduced amount of time spent on landfill trips (due to high compaction packer vehicles) System B provides approximately the same amount of productive time on route as System A (571 crew-hr/wk). System B can get the total job done with less collection crews operating at the same on-route productivity as System A with the collection personnel working the same average number of hours each day. It has been illustrated that System B will be more productive on a per day basis (pickups/crew-day) due to an increase in on-route time because fewer landfill trips are required.

An increase in productivity means little unless it can be translated into a cost savings. In this example the System B crews spend more time on-route per day and can thus make more pick-ups than the System A crews. As a result System B can operate using three less crews. Cost estimates have been done to illustrate the cost savings that could occur. Tables 4.3 and 4.4 show life cycle cost estimates for the types of vehicles being considered. Tables 4.5 and 4.6 show estimates of total costs for Systems A and B respectively. The results of the cost estimates are as follows:

<u>System</u>	<u>Estimated Total Annual Cost</u>
A	\$ 2,308,000/yr
B	<u>\$ 2,079,000/yr</u>
Savings	\$ 229,000/yr

TABLE 4.2
TIME UTILIZATION ESTIMATES FOR
SYSTEMS A AND B

<u>System Using Present Equipment Inventory (System A)</u>	
Number of crews	29
Total task time(1)	798 crew-hr/wk
Time spent on:	
Driving to route and vehicle wash(2)	44 crew-hr/wk
Landfill trips(3)	180 crew-hr/wk
Productive (on-route) time	574 crew-hr/wk
Required productivity(4)	311 pick-up/crew-hr (on route)
<u>System Using All Auger Type Packers (System B)</u>	
Number of crews	26
Total task time(1)	718 crew-hr/wk
Time spent on:	
Driving to route and vehicle wash(2)	40 crew-hr/wk
Landfill trips(5)	107 crew-hr/wk
Productive (on-route) time	571 crew-hr/wk
Required productivity(4)	312 pick-up/crew-hr (on route)
(1) Assume year-round average of 6.9 hr/crew-day	
(2) Estimate year-round average of 0.38 hr/crew-day	
(3) See Table 4.1 for estimate	
(4) Based on 89,200 homes served with 2 pick-ups per week	
(5) Estimate year-round average of 4.1 hr/crew-week	

TABLE 4.3
LIFE CYCLE COSTS - 20-CU YD REAR LOADER (CONVENTIONAL)

Year: _____	1	2	3	4	5
<u>Capital Investment and Depreciation:</u>					
Trade-in value (% of delivery price)	75	55	40	30	25
Investment, start (\$)	41,000	30,750	22,550	16,400	12,300
Year-end value (\$)	30,750	22,550	16,400	12,300	10,250
Yearly capital cost (\$)	10,250	8,200	6,150	4,100	2,050
<u>Debt Service and Insurance:</u>					
Average yearly worth (\$)(1)	35,875	26,650	19,475	14,350	11,275
Yearly debt cost @ 12% (\$)	4,305	3,198	2,337	1,722	1,353
<u>Maintenance:</u>					
Yearly estimate (% of delivery price)	4.5	6.5	10.5	16.5	22.5
Yearly estimated cost (\$)	1,845	2,665	4,305	6,765	9,225
Fuel & Oil (\$)	3,000	3,000	3,000	3,000	3,000
<u>Downtime:</u>					
Availability factor (%)(3)	95	94	91	88	85
Hours not available	83	100	150	200	250
Cost @ \$10/hr	830	1,000	1,500	2,000	2,500
<u>Productivity Loss due to Age(2):</u>					
Productivity factor(3)	98	96	94	92	90
Extra hours required to match					
Production of new model	33	67	100	133	166
Cost @ \$10/hr	330	670	1,000	1,330	1,660
Total Annual Cost (\$)	20,560	18,733	18,292	18,917	19,798
Cumulative Vehicle Cost (\$)	20,560	39,293	57,585	76,502	96,290

$$\text{Average Annual Cost} = 96,290/5 = \underline{\$19,300}$$

- (1) Average between worth at beginning of year and worth at end of year.
 (2) Accounts for loss of productivity as equipment ages.
 (3) Average for year

TABLE 4.4

LIFE CYCLE COSTS - 20-CU YD REAR LOADER (AUGER TYPE)
AND 25-CU YD REAR LOADER (CONVENTIONAL)

Year:	1	2	3	4	5
<u>Capital Investment and Depreciation:</u>					
Trade-in value (% of delivery price)	75	55	40	30	25
Investment, start (\$)	43,000	32,250	23,650	17,200	12,900
Year-end value (\$)	32,250	23,650	17,200	12,900	10,750
Yearly capital cost (\$)	10,750	8,600	6,450	4,300	2,150
<u>Debt Service and Insurance:</u>					
Average yearly worth (\$)(1)	37,625	27,950	20,425	15,050	11,825
Yearly debt cost @ 12% (\$)	4,515	3,354	2,451	1,806	1,419
<u>Maintenance:</u>					
Yearly estimate (% of delivery price)	4.5	6.5	10.5	16.5	22.5
Yearly estimated cost (\$)	1,935	2,795	4,515	7,095	9,675
Fuel & Oil (\$)	3,000	3,000	3,000	3,000	3,000
<u>Downtime:</u>					
Availability factor (%) (3)	95	94	91	88	85
Hours not available	33	100	150	200	250
Cost @ \$10/hr	830	1,000	1,500	2,000	2,500
<u>Productivity Loss due to Age(2):</u>					
Productivity factor(3)	98	96	94	92	90
Extra hours required to match					
Production of new model	33	67	100	133	166
Cost @ \$10/hr	330	670	1,000	1,330	1,660
Total Annual Cost (\$)	21,360	19,419	18,916	19,531	20,404
Cumulative Vehicle Cost (\$)	21,360	40,779	59,695	79,226	99,630

$$\text{Average Annual Cost} = 96,290/5 = \underline{\$19,900}$$

- (1) Average between worth at beginning of year and worth at end of year.
 (2) Accounts for loss of productivity as equipment ages.
 (3) Average for year

TABLE 4.5

ANNUAL COST ESTIMATE - SYSTEM USING PRESENT
EQUIPMENT INVENTORY (SYSTEM A)

<u>Labor</u> (29 crews)			
29 Drivers	\$6.73/hr	-	406,000
87 Walkers	\$4.35/hr	-	<u>787,000</u>
Total Wages		-	1,193,000
Fringe benefits (30%)		-	358,000
Personnel overhead (10%)		-	119,000
Absenteeism (6%)		-	<u>72,000</u>
Total Labor Cost			\$1,742,000
 <u>Equipment</u> (1)			
20-cu yd rear loaders-conventional (19 @ \$19,300/yr)(2)			367,700
25-cu yd rear loaders-conventional (6 @ \$19,900/yr)(3)			119,000
20-cu yd rear loaders-auger type (4 @ \$19,900/yr)(3)			<u>80,000</u>
Total Equipment cost			\$ 566,000
TOTAL ANNUAL COST =			<u>\$2,308,000</u>
UNIT COST =			<u>\$ 25.9/home-year</u>

(1) See Table 4.1 for equipment type usage

(2) See Table 4.3 for life cycle cost estimate

(3) See Table 4.4 for life cycle cost estimate.

TABLE 4.6

ANNUAL COST ESTIMATE - SYSTEM USING ONLY
AUGER TYPE PACKERS (SYSTEM B)Labor (28 crews)

26 Drivers	\$6.73/hr	-	364,000
78 Walkers	\$4.35/hr	-	<u>706,000</u>
Total Wages		-	1,070,000
Fringe benefits (30%)		-	321,000
Personnel overhead (10%)		-	107,000
Absenteeism (6%)		-	<u>64,000</u>
Total Labor Cost			\$1,562,000

Equipment

20-cu yd rear loaders-auger type (26 @ \$19,900/yr)(1)		<u>517,000</u>
Total Equipment Cost		\$ 517,000
TOTAL ANNUAL COST =		<u>\$2,079,000</u>
UNIT COST =		<u>\$23.3/home-year</u>

(1) See Table 4.4 for life cycle cost estimate.

It is estimated that an annual savings of about \$229,000/yr could be realized if System A were operated using the same type of equipment and number of crews as System B.

SUMMARY

An example was presented showing how the total annual operating costs of the BMRCs could be reduced by exclusive use of high compaction packer vehicles. It was necessary to make a number of assumptions and the example is intended for illustrative purposes alone. However, the basic concepts which were illustrated by the example are very real and could have application with the BMRCs. To perform a more detailed analysis it would be necessary to determine more accurately the amount of time presently being spent on landfill trips in Birmingham. This could easily be measured by having the collection vehicle drivers keep logs of how many landfill trips they make each day and how long it is taking them to get back on-route.

Based on the material presented in this chapter the following conclusion has been formed:

- o The use of high compaction refuse collection vehicles has potential for reducing the total operating costs of the BMRCs.

CHAPTER 5

BIRMINGHAM SYSTEM SAFETY

CHAPTER 5

BIRMINGHAM SYSTEM SAFETY

The objective of this chapter is to examine the record and current practices of the Birmingham Municipal Refuse Collection System (BMRCs) from a safety point of view.

SAFETY RECORD

The U.S. EPA began a detailed study of the occurrence of injuries to refuse collection workers in January, 1976. The BMRCs participated in this study along with 55 other refuse collection systems. The sizes of the organizations ranged from 8 to 844 employees and were selected from all over the United States.

Of the 56 study systems, 6 have been selected here as being comparable to the BMRCs based on the following criteria:

- o All collected from curbside and alley or curbside alone
- o All used a task incentive program
- o All disposed of refuse at a landfill and/or transfer station
- o All had 50 or more employees (as would be expected the smaller systems produced erratic data).

Several important safety parameters which were measured during the study are defined below:

- o OSHA Incidence Rate - The number of OSHA recordable injuries (injuries which require more than first aid) per 200,000 hours of exposure. Can be thought of as the number of injuries per 100 workers per year.

- o OSHA Severity Rate - Number of OSHA days lost (lost workdays or light duty days) per 200,000 hours of exposure (number of days lost per 100 workers per year).
- o Average Cost Per Man-Year - The Average cost to the operating organization due to injuries per worker per year.

The previously defined parameters are summarized in Table 5.1 for the first 9 months of the study. The average data is shown individually for the BMRCs, the 7 comparable systems and all study systems (note that the BMRCs is included in the other two groups). It can be seen that the average injury incidence rate, injury severity rate and injury cost factors for the BMRCs are lower than the averages for the comparable group as well as the total group. It can be said that during the first three quarters of the study that the BMRCs was having less serious injuries and was losing less time and money per employee than the other study systems.

COLLECTION PROCEDURES

Worker Safety

During the course of this study various BMRCs crews have been followed and observed on a number of occasions. During these periods no worker injuries have been observed. However several worker practices were noted that could cause injury. These are listed below:

- o Walkers throwing empty garbage cans to each other
- o Walkers picking-up refuse from moving vehicle
- o Walkers jumping on moving vehicle
- o Walkers placing hands or feet into compacting compartment during packing cycle (to control spilling refuse)

Equipment Safety

Of the BMRCs vehicles observed only one significant hazard problem was noted. The mechanism on the auger type packer vehicles

TABLE 5.1
SUMMARY OF DATA FROM FIRST THREE QUARTERS OF EPA SAFETY STUDY

	Reporting (1)		Average (2) OSHA Incidence Rate	Average (3) Severity Rate	Average (4) Cost Per Man-Year (\$)
	Number of Systems	Number of Quarters			
Birmingham	1	3	31	143	108
Comparable System(5)	7	21	54	316	161
All Systems(6)	56	131	45	334	168

(1) Taken from "Accident Trends in the Solid Waste Management Industry", Third Quarterly Report (July 1 through September 30, 1976), U.S. EPA.

(2) Number of OSHA recordable injuries per 200,000 hours exposure (100 man-years). Average for 3 quarters.

(3) Number of OSHA days lost (workdays lost and light duty days) per 200,000 hours of exposure (100 man-year).

(4) Average cost to organization per employee per year.

(5) Systems comparable to Birmingham based on container placement, incentive program and disposal facility. Includes Birmingham.

(6) All systems that participated in study.

can at times bind a full liquid container and crush it so that liquid will be squirted out of the back of the vehicle, towards the area where walkers are working. This occurrence was observed several times. If a closed container of a hazardous liquid (acid, strong bleach, etc.) were to burst in this fashion and a walker was hit, it could cause an injury (eye injury, etc.). It is also possible that solid debris could be ejected. The auger type vehicles are equipped with a rubber flap screen to help contain material which might be ejected. One of the auger units observed, however, had a screen which was missing a good number of its flaps. In this case the screen would not effectively protect the walkers. This unit and any other pieces of BMRCs equipment which have this problem should be repaired.